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Effect of Natural Fibers from Palm Fronds on The Mechanical Properties of Concrete

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ABSTRACT

Scientists have recently started looking for new ecologically friendly and sustainable materials. Construction materials are among the numerous widely employed materials, and it is normally acknowledged that they have an apparent detrimental influence on the environment. Thus, the contribution of this paper is to describe the palm frond natural fibers' effect on concrete's mechanical characteristics. Since concrete is a brittle material, the goal of this research is to increase the tensile strength of concrete by using organic fibers (palm frond fibers), a waste product. In order to determine the ideal percentage of fibers, the following percentages were tested: 0.25, 0.5, 0.75, and 1% by volume of concrete. On dry density, compressive strength, and tensile strength, the impacts of fibers were investigated. The density of concrete decreased with increasing fiber ratios. The compressive strength slightly decreased, while the splitting strength significantly improved. According to the results, the best amount of palm frond fibers that can be add to concrete is 0.75% by volume.

1. Introduction

Cement-based matrices comprised of paste, mortar, or concrete have been reinforced with a variety of fiber types in a range of sizes, both natural and synthetic. The most economically important forms of fibers range from natural organics like cellulose or sisal to synthetic inorganics like steel or glass, synthetic organics like polypropylene or carbon, and natural inorganics like asbestos. The use of high alumina cement and cement with additives like fly ash, slag, silica fume, etc. to improve the composite's durability or minimize chemical interactions between the fibers and matrix have also been reported [1]. However, the majority of developments still involve the use of normal Portland cement.

Since the study's findings revealed that the developed composites meet the majority of the requirements of various standards on cement-bonded particle boards and have high levels of performance even in moist conditions, Aggarwal [2] suggested using bagasse to create cement-bonded construction materials. in nations where it is widely available. When creating composite reinforced coconut fiber, coconut fibers can be used to reinforce sand. Additionally, increasing the amount of coconut fiber in the composites enhanced their compressive strength and rupture modulus up to an ideal composition.

Natural fibers have a low elastic modulus and a high tensile strength. but they vary widely in these characteristics, which could result in unpredictable fiber-cement composite properties [3,4]. Numerous studies have evaluated the usage of various natural fiber types in concrete and mortar applications.

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Kriker et al. investigated the notion of using date palm fibers as reinforcement in concrete (5). The mechanical and strength properties of date palm surface fibers in dry and hot climates have been examined.

In various applications, natural fibers, whether treated or not, have been employed to reinforce cement-based materials. applications in numerous countries. These include products made from various plant sections. For example, the stem is used to make jute, ramie, flax, kenaf, and hemp fibers, while the leaves are used to make sisal, banana, and pineapple, and the seeds are used to make cotton and kapok. According to Filho et al. [6] and John et al. [7], natural fibers are composites with a cellular structure made up of various ratios of cellulose, hemicellulose, and lignin that make up various layers. Merta and Tschegg [8] presented an experimental investigation of the fracture energy of concrete strengthened with wheat straw, elephant grass, and the natural fibers of hemp. Sivaraja et al. [9] employed microstructural properties and mechanical strength to examine the durability of natural fiber composites for concrete. The natural fibers' characteristics as they relate to concrete composites for structural purposes were presented by Sivaraja and Kandasam [10]. Aziz et al. [11] offered the current past and present studies and improvements for the effective usage of natural fibers from wood, jute, bamboo, sugarcane bagasse, sisal, plantain, muamba, and coconut husk for making concrete. More and Subramanian [12] studied the influence of fibers on the durability and mechanical characteristics of fiber-reinforced concrete. Machaka et al. [13] examined the influence of employing fan palm natural fibers on the durability and mechanical properties of concrete. To the best of the authors' knowledge, there have not been any investigations into the impact of natural fibers from palm fronds on the mechanical properties of concrete.

2. The materials used, mixing proportions, and experimentally tests

The entire investigation was conducted using Portland cement. Physically, it complies with the modified Iraqi standard specification for 2019. For casting the specimens, sand from Al-Ekhaider was used. The fine aggregate had a specific gravity of 2.67, a fineness modulus of SO3 of 2.63, and a fineness percentage of 0.1%. In addition, the density of palm fronds used is 350 kg/m^3. Using the Iraqi specification No. 45/ 1984 as a guide, zone (2) was designated as the fine aggregate grading zone. From the Al-Nibaee region, crushed coarse aggregate was used. a coarse aggregate with a maximum size of 12.5 mm, a specific gravity of 2.67, and a SO3 content of 7%, respectively. Their grading and other characteristics complied with Iraqi specification No. 45/ 1984 [14]. In this experiment, palm frond fibers were utilized. The fibers in palm fronds have a density of 350 kg/m3, a diameter of (0.2-0.3) mm, and a length of almost (3) mm, as shown in figure 2. Percentages of palm fronds were added after cutting them to a size of 1 mm in specific proportions to replace them with the used cemetery. The ratios used were as follows: 5, 10, and 15% of the total volume of cement to increase the strength. Fibers can be used as main or secondary reinforcement in concrete. When traditional reinforcing bars cannot be employed and there is no coarse aggregate and a matrix with significantly more cement than typical concrete, fibers act as the principal reinforcement. To improve the composite's strength and durability, the fibers are employed as the main reinforcement. Additionally, fibers are used as additional reinforcement in the matrix to prevent cracking brought on by changes in temperature or humidity, as well as to offer post-failure integrity in the case of an accidentally overloading or spalling [1], [6]. Besides date palm trees are indigenous to the middle east; nations like Iraq may easily and freely find their fibers. Therefore, this research was made to take advantage of the property of fibers and their availability of it. The results of the sieve investigation of utilizing coarse aggregates are given in Fig. 1.

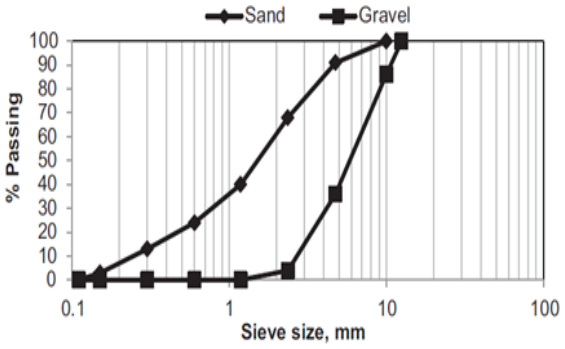
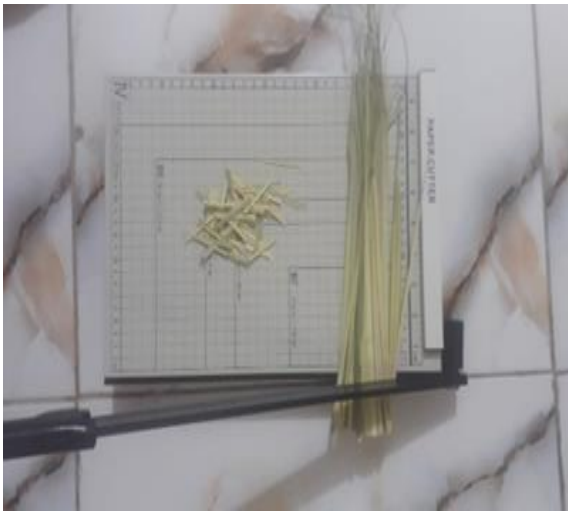


Figure1. Sieve analysis of sand and crushed stone.



(a)

(b)

(c)

Figure 2. plan fronds fibers

For all mix the mix 1:2:3 (cement Portland: sand:gravel) was used with 0.42 water/cement ratio, the percentages of fibers were 0.25, 0.5, 0.75, and 1% by volume of concrete. In a pan mixer with a capacity of 0.1 m^3, all materials (fibers included or not) were uniformly blended. Using a vibrating table, the compaction process took place for 20 seconds per layer. The samples were removed from the casting after 24 hours. Concrete samples were then moist-cured at 25°C until being tested for age. Using 100 mm cubes, the compressive strength test was conducted based on BS EN (12390-3:2002) [15]. The test apparatus is an ELE machine with a 2000kN load capacity and a loading rate of 0.3 N/mm2/s. Using (100 x 200) mm cylinders, the splitting tensile strength was measured in accordance with ASTM C496-04 [16]. The test was run at a loading rate of 0.1 N/mm2/sec

3. Results and Discussion

3.1 dry density

The test findings were presented in Figure 3. The density of all mixes decreased with increasing of this fiber's contents. The reason behind this behavior is the low density of these fibers.

3.2 Compressive strength

The test findings were presented in Figure 4. The compressive strength of all mixes decreased slightly with increasing of this fiber's contents. This loss in compressive strength may be caused by the voids that are created when those fibers are added to the mixture [17].

3.3 splitting strength

The test findings were presented in Figure 5. The splitting strength increased with the increase of fibers. The results show that adding a percentage more than 0.75 percent to the mixture reduces the tensile strength. This could be because employing such larger fiber percentages makes it more difficult to produce uniform and evenly dispersed fibers in the mixture [17].

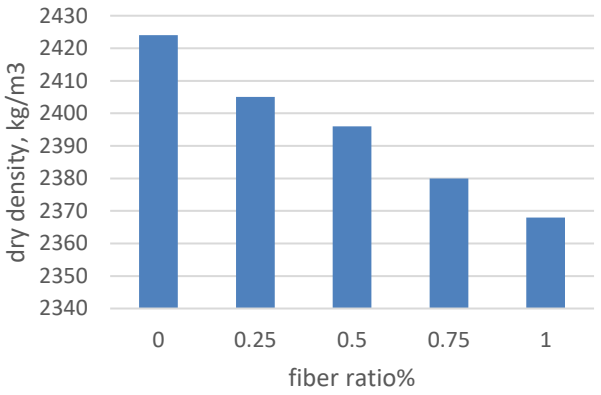


Figure 3: Dry density vs. fiber ratio.

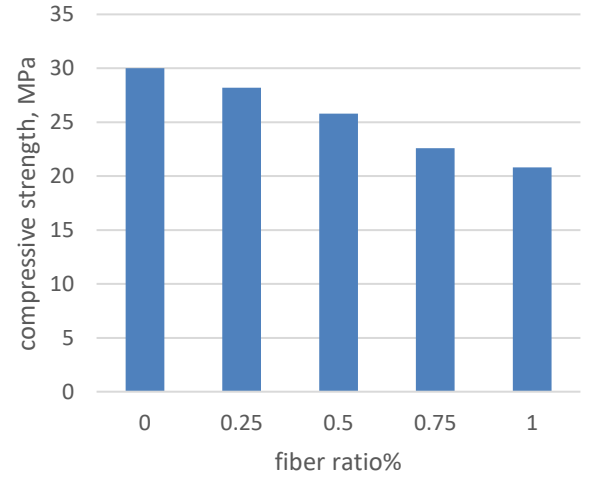


Figure 4: Compressive strength vs. fiber ratio

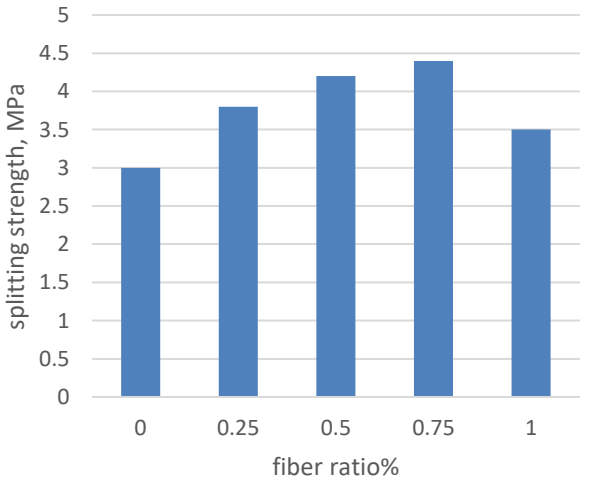


Figure 5: splitting strength vs. fiber ratio

4. onclusions

The density of concrete decreased with increasing fibers contents. The increasing fibers contents caused to decrease slightly in the compressive strength. The splitting strength of concrete increased with increasing fibers contents. But it begain to decrease at 1% . This type of fibers can be succefully be used in concrete.

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